Effectively and Securely Using the Cloud Computing Paradigm

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NIST Cloud Computing Resources

- NIST Draft Definition of Cloud Computing
- Presentation on Effective and Secure Use of Cloud Computing

- http://csrc.nist.gov/groups/SNS/cloud-computing/index.html

Caveats and Disclaimers

- This presentation provides education on cloud technology and its benefits to set up a discussion of cloud security

- It is NOT intended to provide official NIST guidance and NIST does not make policy

- Any mention of a vendor or product is NOT an endorsement or recommendation

Citation Note: All sources for the material in this presentation are included within the Powerpoint "notes" field on each slide

Agenda

- Part 1: Effective and Secure Use
  – Understanding Cloud Computing
  – Cloud Computing Security
  – Secure Cloud Migration Paths
  – Cloud Publications
  – Cloud Computing and Standards

- Part 2: Cloud Resources, Case Studies, and Security Models
  – Thoughts on Cloud Computing
  – Foundational Elements of Cloud Computing
  – Cloud Computing Case Studies and Security Models

Part I: Effective and Secure Use

Understanding Cloud Computing

Origin of the term "Cloud Computing"

- "Comes from the early days of the Internet where we drew the network as a cloud… we didn't care where the messages went… the cloud hid it from us" – Kevin Marks, Google

- First cloud around networking (TCP/IP abstraction)

- Second cloud around documents (WWW data abstraction)

- The emerging cloud abstracts infrastructure complexities of servers, applications, data, and heterogeneous platforms
  - ("muck" as Amazon's CEO Jeff Bezos calls it)

A Working Definition of Cloud Computing

- Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

- This cloud model promotes availability and is composed of five essential **characteristics,** three **service models**, and four **deployment models**.

5 Essential Cloud Characteristics

- On-demand self-service
- Broad network access
- Resource pooling
  - Location independence
- Rapid elasticity
- Measured service

3 Cloud Service Models

- **Cloud Software as a Service (SaaS)**
  - Use provider's applications over a network
- **Cloud Platform as a Service (PaaS)**
  - Deploy customer-created applications to a cloud
- **Cloud Infrastructure as a Service (IaaS)**
  - Rent processing, storage, network capacity, and other fundamental computing resources

- **To be considered "cloud" they must be deployed on top of cloud infrastructure that has the key characteristics**

Service Model Architectures

Cloud Infrastructure	Cloud Infrastructure	Cloud Infrastructure
SaaS	PaaS SaaS	IaaS PaaS SaaS
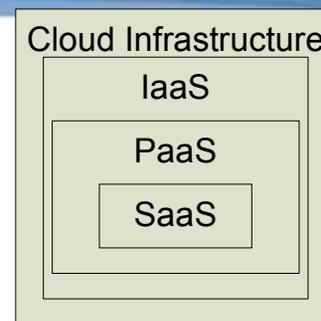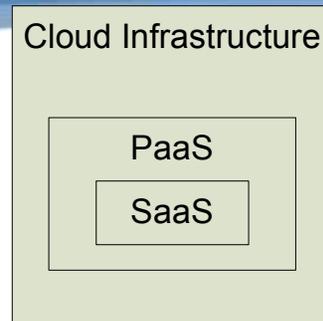
Software as a Service (SaaS) Architectures

Cloud Infrastructure	Cloud Infrastructure
PaaS	IaaS PaaS
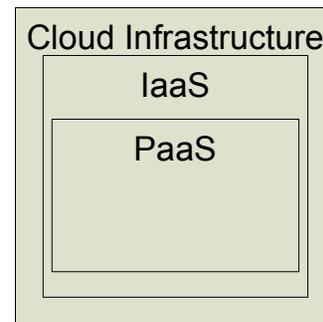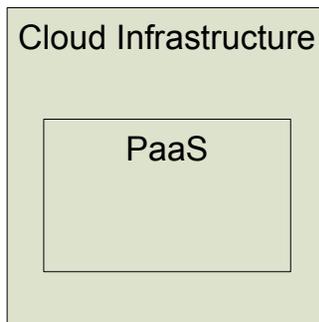
Platform as a Service (PaaS) Architectures

Cloud Infrastructure
IaaS
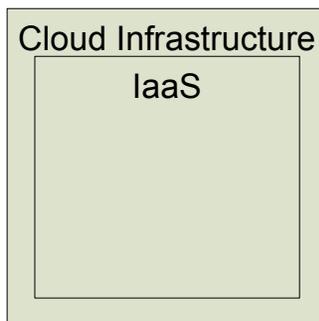
Infrastructure as a Service (IaaS) Architectures

4 Cloud Deployment Models

- Private cloud
  - enterprise owned or leased
- Community cloud
  - shared infrastructure for specific community
- Public cloud
  - Sold to the public, mega-scale infrastructure
- Hybrid cloud
  - composition of two or more clouds

Common Cloud Characteristics

- Cloud computing often leverages:
  - Massive scale
  - Homogeneity
  - Virtualization
  - Resilient computing
  - Low cost software
  - Geographic distribution
  - Service orientation
  - Advanced security technologies

The NIST Cloud Definition Framework

Hybrid Clouds

Deployment Models

Private Cloud   **Community Cloud**   **Public Cloud**

Service Models

| Software as a Service (SaaS) | Platform as a Service (PaaS) | Infrastructure as a Service (IaaS) |

Essential Characteristics

On Demand Self-Service

| Broad Network Access | Rapid Elasticity |
| Resource Pooling | Measured Service |

Common Characteristics

| Massive Scale | Resilient Computing |
Homogeneity	Geographic Distribution
Virtualization	Service Orientation
Low Cost Software	Advanced Security

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Cloud Computing Security

Security is the Major Issue

Q: Rate the **challenges/issues** ascribed to the 'cloud'/on-demand model
(1=not significant, 5=very significant)

Challenge/Issue	% responding 4 or 5
Security	74.6%
Performance	63.1%
Availability	63.1%
Hard to integrate with in-house IT	61.1%
Not enough ability to customize	55.8%
Worried on-demand will cost more	50.4%
Bringing back in-house may be difficult	50.0%
Regulatory requirements prohibit cloud	49.2%
Not enough major suppliers yet	44.3%

% responding 4 or 5
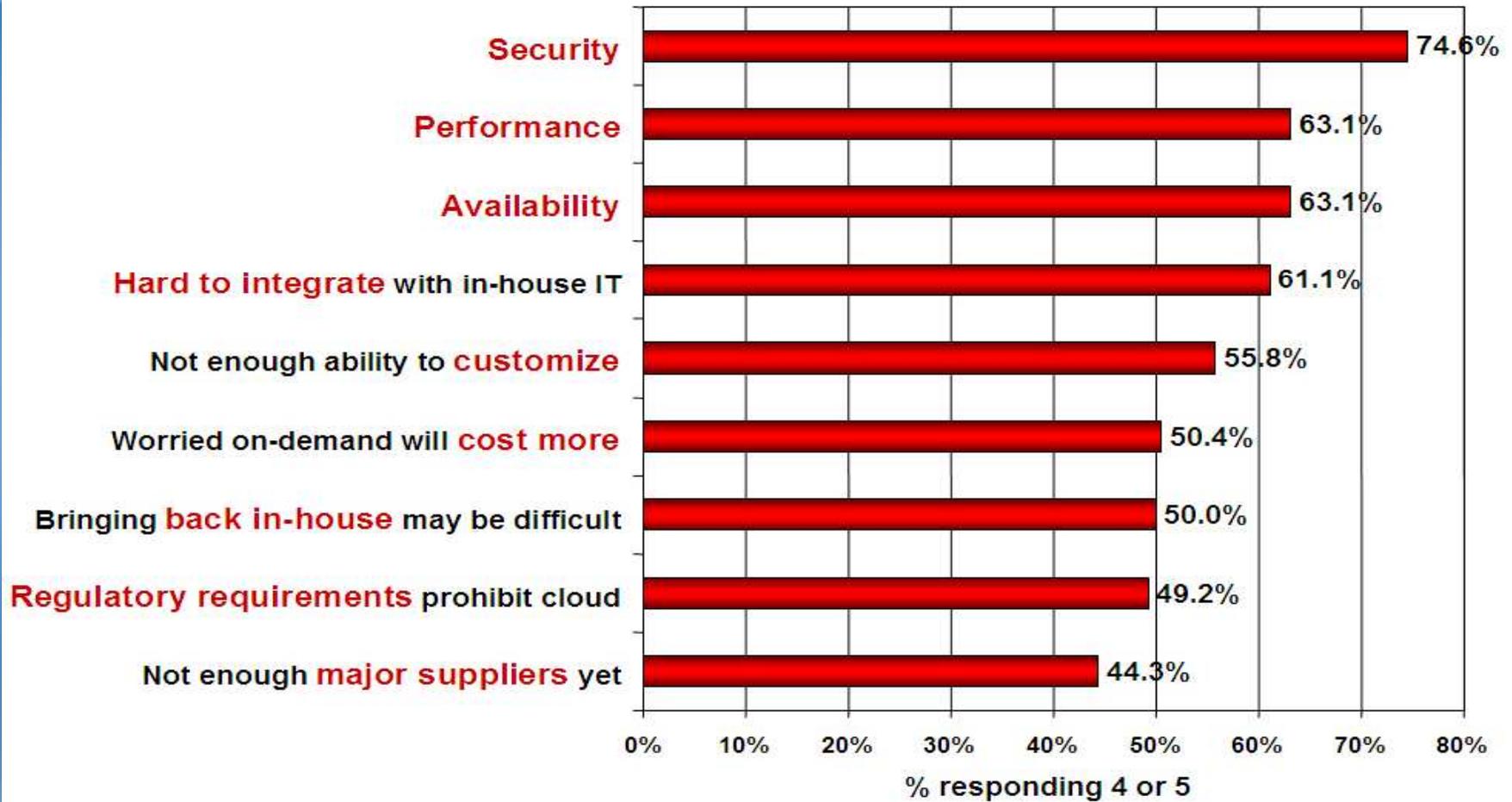
Source: IDC Enterprise Panel, August 2008 n=244

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Analyzing Cloud Security

- Some key issues:
    - trust, multi-tenancy, encryption, compliance
- Clouds are massively **complex systems** can be reduced to **simple primitives** that are replicated thousands of times and **common functional units**
- Cloud security is a tractable problem
    - There are both advantages and challenges

Former Intel CEO, Andy Grove: "only the paranoid survive"

General Security Advantages

- Shifting public data to a external cloud reduces the exposure of the internal sensitive data

- Cloud homogeneity makes security auditing/testing simpler

- Clouds enable automated security management

- Redundancy / Disaster Recovery

General Security Challenges

- Trusting vendor's security model
- Customer inability to respond to audit findings
- Obtaining support for investigations
- Indirect administrator accountability
- Proprietary implementations can't be examined
- Loss of physical control

Security Relevant Cloud Components

- Cloud Provisioning Services

- Cloud Data Storage Services

- Cloud Processing Infrastructure

- Cloud Support Services

- Cloud Network and Perimeter Security

- Elastic Elements: Storage, Processing, and Virtual Networks

Provisioning Service

- Advantages
  - Rapid reconstitution of services
  - Enables availability
    - Provision in multiple data centers / multiple instances
  - Advanced honey net capabilities
- Challenges
  - Impact of compromising the provisioning service

Data Storage Services

- Advantages
  - Data fragmentation and dispersal
  - Automated replication
  - Provision of data zones (e.g., by country)
  - Encryption at rest and in transit
  - Automated data retention
- Challenges
  - Isolation management / data multi-tenancy
  - Storage controller
    - Single point of failure / compromise?
  - Exposure of data to foreign governments

Cloud Processing Infrastructure

- Advantages
  - Ability to secure masters and push out secure images

- Challenges
  - Application multi-tenancy
  - Reliance on hypervisors
  - Process isolation / Application sandboxes

Cloud Support Services

- ## Advantages
  - On demand security controls (e.g., authentication, logging, firewalls…)

- ## Challenges
  - Additional risk when integrated with customer applications
  - Needs certification and accreditation as a separate application
  - Code updates

Cloud Network and Perimeter Security

- Advantages
  - Distributed denial of service protection
  - VLAN capabilities
  - Perimeter security (IDS, firewall, authentication)
- Challenges
  - Virtual zoning with application mobility

Cloud Security Advantages Part 1

- Data Fragmentation and Dispersal

- Dedicated Security Team

- Greater Investment in Security Infrastructure

- Fault Tolerance and Reliability

- Greater Resiliency

- Hypervisor Protection Against Network Attacks

- Possible Reduction of C&A Activities (Access to Pre-Accredited Clouds)

Cloud Security Advantages
Part 2

- Simplification of Compliance Analysis
- Data Held by Unbiased Party (cloud vendor assertion)
- Low-Cost Disaster Recovery and Data Storage Solutions
- On-Demand Security Controls
- Real-Time Detection of System Tampering
- Rapid Re-Constitution of Services
- Advanced Honeynet Capabilities

Cloud Security Challenges
Part 1

- Data dispersal and international privacy laws
  - EU Data Protection Directive and U.S. Safe Harbor program
  - Exposure of data to foreign government and data subpoenas
  - Data retention issues
- Need for isolation management
- Multi-tenancy
- Logging challenges
- Data ownership issues
- Quality of service guarantees

Cloud Security Challenges
Part 2

- Dependence on secure hypervisors
- Attraction to hackers (high value target)
- Security of virtual OSs in the cloud
- Possibility for massive outages
- Encryption needs for cloud computing
  - Encrypting access to the cloud resource control interface
  - Encrypting administrative access to OS instances
  - Encrypting access to applications
  - Encrypting application data at rest
- Public cloud vs internal cloud security
- Lack of public SaaS version control

Additional Issues

- Issues with moving PII and sensitive data to the cloud
  - Privacy impact assessments
- Using SLAs to obtain cloud security
  - Suggested requirements for cloud SLAs
  - Issues with cloud forensics
- Contingency planning and disaster recovery for cloud implementations
- Handling compliance
  - FISMA
  - HIPAA
  - SOX
  - PCI
  - SAS 70 Audits

Secure Migration Paths
for Cloud Computing

The 'Why' and 'How' of Cloud Migration

- There are many benefits that explain **why** to migrate to clouds
  - Cost savings, power savings, green savings, increased agility in software deployment
- Cloud security issues may drive and define **how** we adopt and deploy cloud computing solutions

Balancing Threat Exposure and Cost Effectiveness

- Private clouds may have less **threat exposure** than community clouds which have less threat exposure than public clouds.

- Massive public clouds may be more **cost effective** than large community clouds which may be more cost effective than small private clouds.

- *Doesn't strong security controls mean that I can adopt the most cost effective approach?*

Cloud Migration and Cloud Security Architectures

- Clouds typically have a single security architecture but have many customers with different demands
  - Clouds should attempt to provide configurable security mechanisms
- Organizations have more control over the security architecture of private clouds followed by community and then public
  - This doesn't say anything about actual security
- Higher sensitivity data is likely to be processed on clouds where organizations have control over the security model

Putting it Together

- Most clouds will require very strong security controls

- All models of cloud may be used for differing tradeoffs between threat exposure and efficiency

- There is no one "cloud". There are many models and architectures.

- How does one choose?

Migration Paths for Cloud Adoption

- Use public clouds
- Develop private clouds
  - Build a private cloud
  - Procure an outsourced private cloud
  - Migrate data centers to be private clouds (fully virtualized)
- Build or procure community clouds
  - Organization wide SaaS
  - PaaS and IaaS
  - Disaster recovery for private clouds
- Use hybrid-cloud technology
  - Workload portability between clouds

Possible Effects of Cloud Computing

- Small enterprises use public SaaS and public clouds and minimize growth of data centers
- Large enterprise data centers may evolve to act as private clouds
- Large enterprises may use hybrid cloud infrastructure software to leverage both internal and public clouds
- Public clouds may adopt standards in order to run workloads from competing hybrid cloud infrastructures

Cloud Computing and Standards

Cloud Standards Mission

- Provide guidance to industry and government for the creation and management of relevant cloud computing standards allowing all parties to gain the maximum value from cloud computing

NIST and Standards

- ## NIST wants to promote cloud standards:
  - We want to propose roadmaps for needed standards
  - We want to act as catalysts to help industry formulate their own standards
    - Opportunities for service, software, and hardware providers
  - We want to promote government and industry adoption of cloud standards

Goal of NIST Cloud Standards Effort

- Fungible clouds
  - (mutual substitution of services)
  - Data and customer application portability
  - Common interfaces, semantics, programming models
  - Federated security services
  - Vendors compete on effective implementations
- Enable and foster value add on services
  - Advanced technology
  - Vendors compete on innovative capabilities

A Model for Standardization and Proprietary Implementation

- Advanced features → Proprietary Value Add Functionality

- Core features → Standardized Core Cloud Capabilities
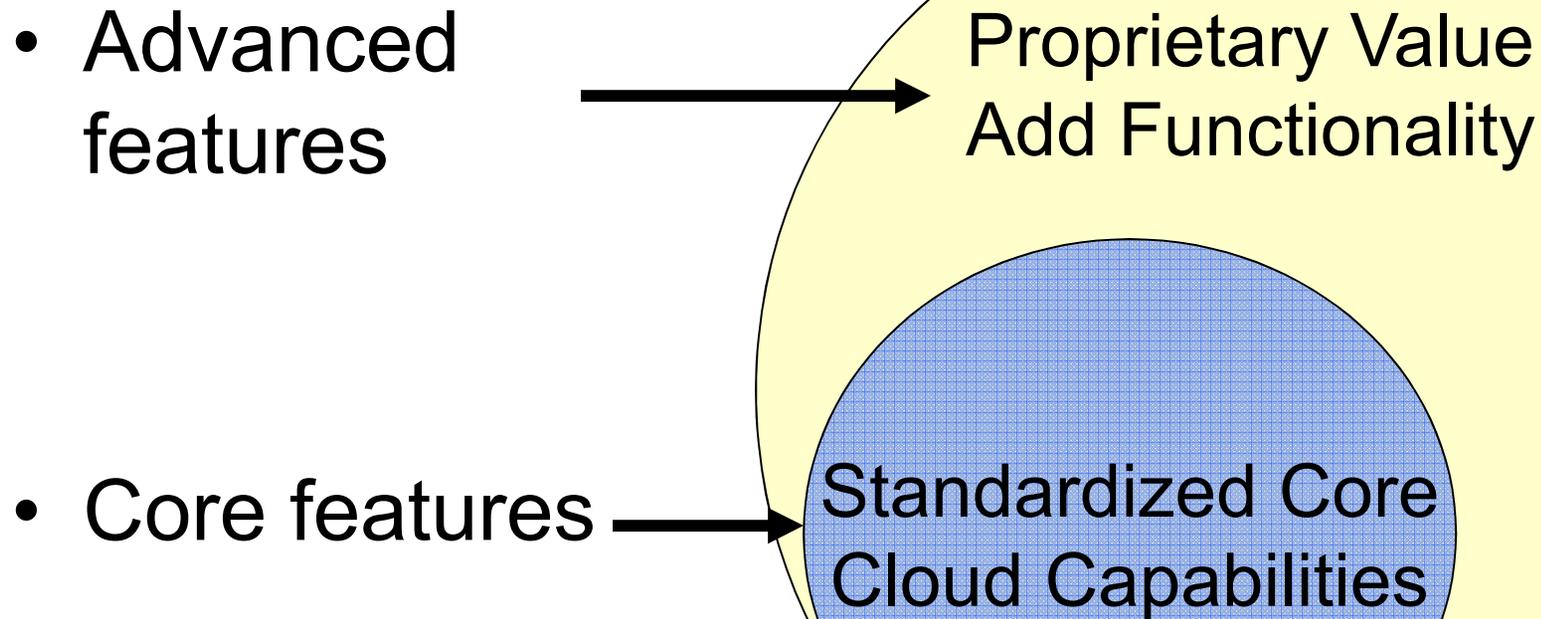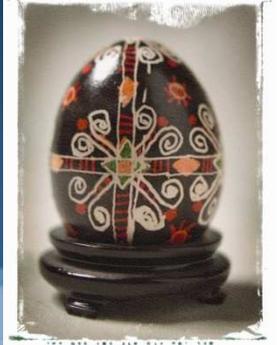
Proposed Result

- Cloud customers knowingly choose the correct mix for their organization of
  - standard portable features
  - proprietary advanced capabilities

A proposal: A NIST Cloud Standards Roadmap

- We need to define minimal standards
  - Enable secure cloud integration, application portability, and data portability
  - Avoid over specification that will inhibit innovation
  - Separately addresses different cloud models

Towards the Creation of a Roadmap (I)

- ## Thoughts on standards:
  - Usually more service lock-in as you move up the SPI stack (IaaS->PaaS->SaaS)
  - IaaS is a natural transition point from traditional enterprise datacenters
    - Base service is typically computation, storage, and networking
  - The virtual machine is the best focal point for fungibility
  - Security and data privacy concerns are the two critical barriers to adopting cloud computing

# Towards the Creation of a Roadmap (II)

- Result:
  - Focus on an overall IaaS standards roadmap as a first major deliverable
  - Research PaaS and SaaS roadmaps as we move forward
  - Provide visibility, encourage collaboration in addressing these standards as soon as possible
  - Identify common needs for security and data privacy standards across IaaS, PaaS, SaaS

A Roadmap for IaaS

- ## Needed standards
  - VM image distribution (e.g., DMTF OVF)
  - VM provisioning and control (e.g., EC2 API)
  - Inter-cloud VM exchange (e.g., ??)
  - Persistent storage (e.g., Azure Storage, S3, EBS, GFS, Atmos)
  - VM SLAs (e.g., ??) – machine readable
    - uptime, resource guarantees, storage redundancy
  - Secure VM configuration (e.g., SCAP)

A Roadmap for PaaS and SaaS

- More difficult due to proprietary nature
- A future focus for NIST

- Standards for PaaS could specify
  - Supported programming languages
  - APIs for cloud services
- Standards for SaaS could specify
  - SaaS-specific authentication / authorization
  - Formats for data import and export (e.g., XML schemas)
  - Separate standards may be needed for each application space
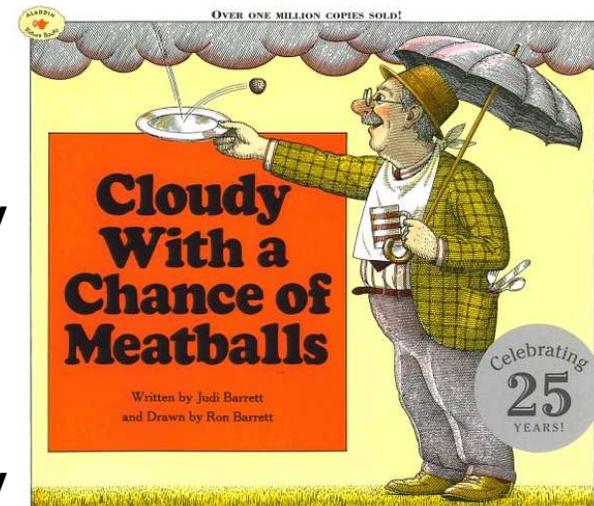
Security and Data Privacy Across IaaS, PaaS, SaaS

- Many existing standards
- Identity and Access Management (IAM)
  - IdM federation (SAML, WS-Federation, Liberty ID-FF)
  - Strong authentication standards (HOTP, OCRA, TOTP)
  - Entitlement management (XACML)
- Data Encryption (at-rest, in-flight), Key Management
  - PKI, PKCS, KEYPROV (CT-KIP, DSKPP), EKMI
- Records and Information Management (ISO 15489)
- E-discovery (EDRM)

Cloud Computing Publications

# Planned NIST
Cloud Computing Publication

- NIST is planning a series of publications on cloud computing

- NIST Special Publication on Cloud
  - What problems does cloud computing solve?
  - What are the technical characteristics of cloud computing?
  - How can we best leverage cloud computing and obtain security?

Part II: Cloud Resources, Case Studies, and Security Models

Thoughts on Cloud Computing
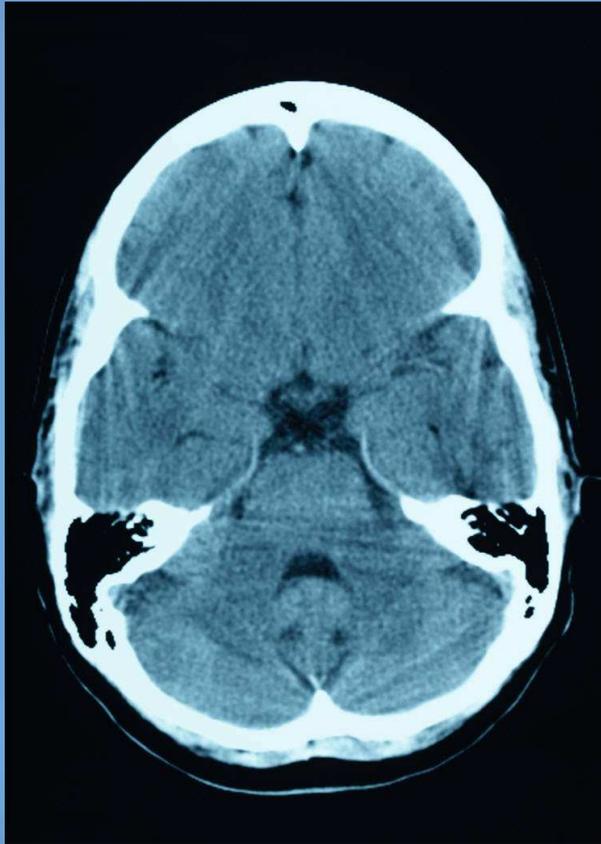
Thoughts on Cloud Computing

- Galen Gruman, InfoWorld Executive Editor, and Eric Knorr, InfoWorld Editor in Chief
  - "A way to increase capacity or add capabilities on the fly without investing in new infrastructure, training new personnel, or licensing new software."
  - "The idea of loosely coupled services running on an agile, scalable infrastructure should eventually make every enterprise a node in the cloud."

Thoughts on Cloud Computing

- Tim O'Reilly, CEO O'Reilly Media
- "I think it is one of the foundations of the next generation of computing"
- "The network of networks is the platform for all computing"
- "Everything we think of as a computer today is really just a device that connects to the big computer that we are all collectively building"

Thoughts on Cloud Computing

- Dan Farber, Editor in Chief CNET News
- "We are at the beginning of the age of planetary computing. Billions of people will be wirelessly interconnected, and the only way to achieve that kind of massive scale usage is by massive scale, **brutally efficient** cloud-based infrastructure."
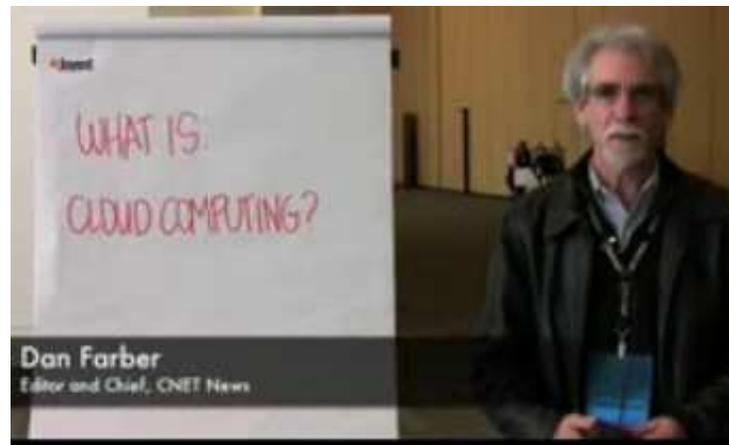
Core objectives of Cloud Computing

- Amazon CTO Werner Vogels
- Core objectives and principles that cloud computing must meet to be successful:
    - Security
    - Scalability
    - Availability
    - Performance
    - Cost-effective
    - Acquire resources on demand
    - Release resources when no longer needed
    - Pay for what you use
    - Leverage others' core competencies
    - Turn fixed cost into variable cost

Amazon CTO Werner Vogels
(Credit: Dan Farber)

A "sunny" vision of the future

- Sun Microsystems CTO Greg Papadopoulos
  - Users will "trust" service providers with their data like they trust banks with their money
  - "Hosting providers [will] bring 'brutal efficiency' for utilization, power, security, service levels, and idea-to-deploy time" –CNET article
  - Becoming cost ineffective to build data centers
  - Organizations will rent computing resources
  - Envisions grid of 6 cloud infrastructure providers linked to 100 regional providers

Foundational Elements of Cloud Computing
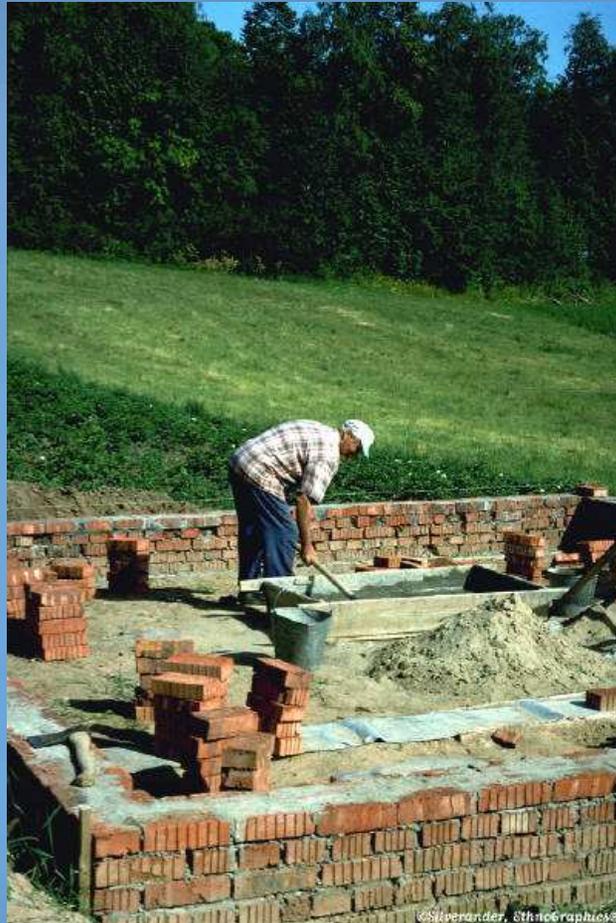
Foundational Elements of Cloud Computing

Primary Technologies

- Virtualization
- Grid technology
- Service Oriented Architectures
- Distributed Computing
- Broadband Networks
- Browser as a platform
- Free and Open Source Software

Other Technologies

- Autonomic Systems
- Web 2.0
- Web application frameworks
- Service Level Agreements

Web 2.0

- Is not a standard but an evolution in using the WWW
- "Don't fight the Internet" – CEO Google, Eric Schmidt
- Web 2.0 is the trend of using the full potential of the web
  - Viewing the Internet as a computing platform
  - Running interactive applications through a web browser
  - Leveraging interconnectivity and mobility of devices
  - The "long tail" (profits in selling specialized small market goods)
  - Enhanced effectiveness with greater human participation
- Tim O'Reilly: "Web 2.0 is the business revolution in the computer industry caused by the move to the Internet as a platform, and an attempt to understand the rules for success on that new platform."

Software as a Service (SaaS)

- SaaS is hosting applications on the Internet as a service (both consumer and enterprise)

- Jon Williams, CTO of Kaplan Test Prep on SaaS

  – "I love the fact that I don't need to deal with servers, staging, version maintenance, security, performance"

- Eric Knorr with Computerworld says that "[there is an] increasing desperation on the part of IT to minimize application deployment and maintenance hassles"

Three Features of Mature SaaS Applications

- ## Scalable
  - Handle growing amounts of work in a graceful manner

- ## Multi-tenancy
  - One application instance may be serving hundreds of companies
  - Opposite of multi-instance where each customer is provisioned their own server running one instance

- ## Metadata driven configurability
  - Instead of customizing the application for a customer (requiring code changes), one allows the user to configure the application through metadata

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SaaS Maturity Levels

- Level 1: Ad-Hoc/Custom
- Level 2: Configurable
- Level 3: Configurable, Multi-Tenant-Efficient
- **Level 4: Scalable, Configurable, Multi-Tenant-Efficient**

Source: Microsoft MSDN Architecture Center
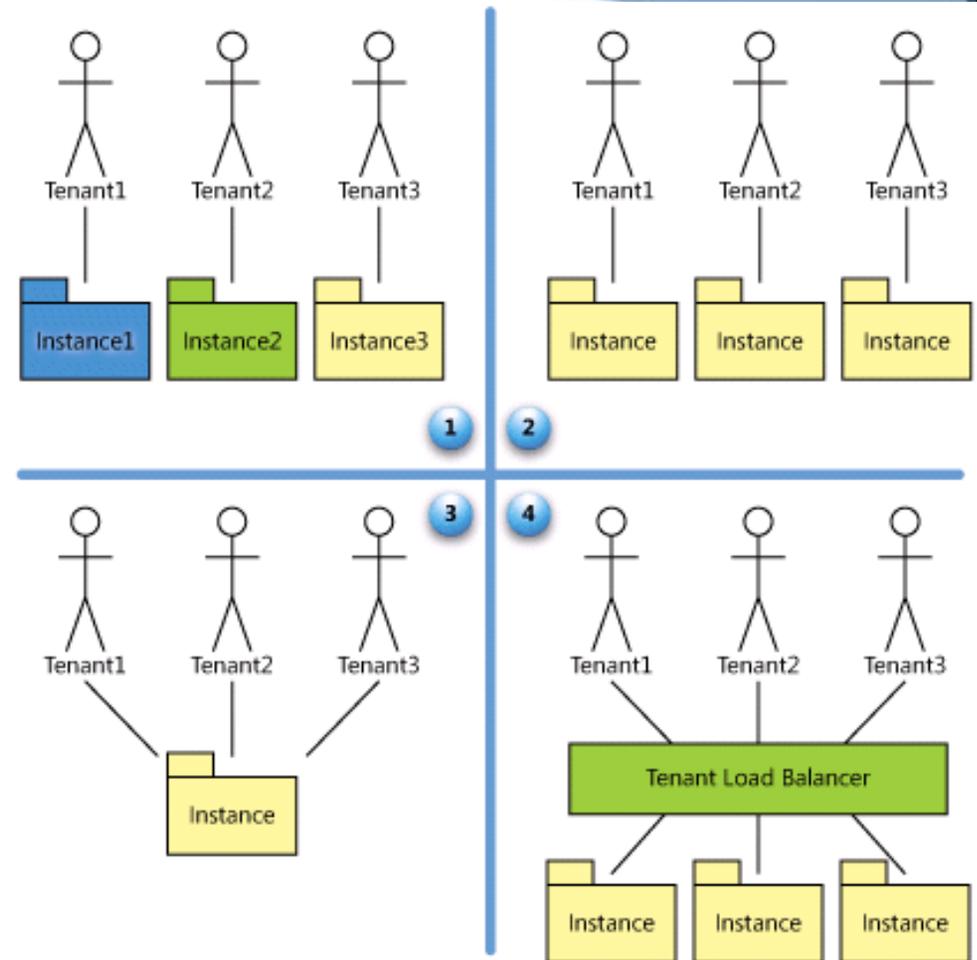
Utility Computing

- "Computing may someday be organized as a public utility" - John McCarthy, MIT Centennial in 1961

- Huge computational and storage capabilities available from utilities

- Metered billing (pay for what you use)

- Simple to use interface to access the capability (e.g., plugging into an outlet)

Service Level Agreements (SLAs)

- Contract between customers and service providers of the level of service to be provided

- Contains performance metrics (e.g., uptime, throughput, response time)

- Problem management details

- Documented security capabilities

- Contains penalties for non-performance

Autonomic System Computing

- Complex computing systems that manage themselves
- Decreased need for human administrators to perform lower level tasks
- Autonomic properties: Purposeful, Automatic, Adaptive, Aware
- IBM's 4 properties: self-healing, self-configuration, self-optimization, and self-protection

IT labor costs are 18 times that of equipment costs.
The number of computers is growing at 38% each year.

Grid Computing

- Distributed parallel processing across a network
- Key concept: "the ability to negotiate resource-sharing arrangements"
- Characteristics of grid computing
  - Coordinates independent resources
  - Uses open standards and interfaces
  - Quality of service
  - Allows for heterogeneity of computers
  - Distribution across large geographical boundaries
  - Loose coupling of computers

Platform Virtualization

- "[Cloud computing] relies on separating your applications from the underlying infrastructure" - Steve Herrod, CTO at VMware
- Host operating system provides an abstraction layer for running virtual guest OSs
- Key is the "hypervisor" or "virtual machine monitor"
  - Enables guest OSs to run in isolation of other OSs
  - Run multiple types of OSs
- Increases utilization of physical servers
- Enables portability of virtual servers between physical servers
- Increases security of physical host server

Web Services
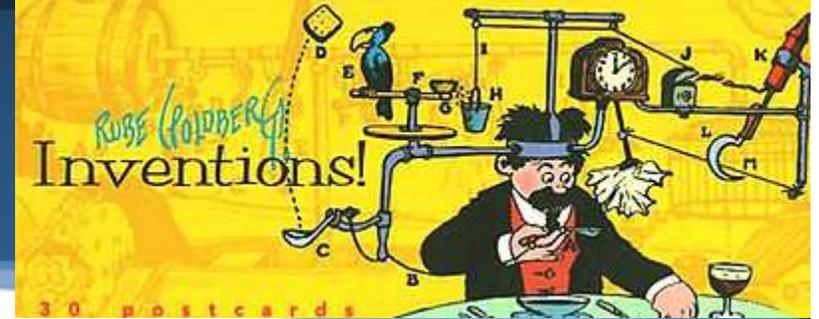
- ## Web Services
  - Self-describing and stateless modules that perform discrete units of work and are available over the network
  - "Web service providers offer APIs that enable developers to exploit functionality over the Internet, rather than delivering full-blown applications." - Infoworld
  - Standards based interfaces (WS-I Basic Profile)
    - e.g., SOAP, WSDL, WS-Security
    - Enabling state: WS-Transaction, Choreography
  - Many loosely coupled interacting modules form a single logical system (e.g., legos)

Service Oriented Architectures

- ## Service Oriented Architectures
  - Model for using web services
    - service requestors, service registry, service providers
  - Use of web services to compose complex, customizable, distributed applications
  - Encapsulate legacy applications
  - Organize stovepiped applications into collective integrated services
  - Interoperability and extensibility

Web application frameworks

- Coding frameworks for enabling dynamic web sites
  - Streamline web and DB related programming operations (e.g., web services support)
  - Creation of Web 2.0 applications
- Supported by most major software languages
- Example capabilities
  - Separation of business logic from the user interface (e.g., Model-view-controller architecture)
  - Authentication, Authorization, and Role Based Access Control (RBAC)
  - Unified APIs for SQL DB interactions
  - Session management
  - URL mapping
- Wikipedia maintains a list of web application frameworks

Free and Open Source Software

- External 'mega-clouds' must focus on using their massive scale to reduce costs
- Usually use free software
  - Proven adequate for cloud deployments
  - Open source
  - Owned by provider
- Need to keep per server cost low
  - Simple commodity hardware
    - Handle failures in software

Public Statistics on Cloud Economics

Cost of Traditional Data Centers
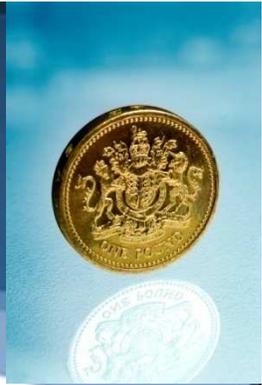
- 11.8 million servers in data centers
- Servers are used at only 15% of their capacity
- 800 billion dollars spent yearly on purchasing and maintaining enterprise software
- 80% of enterprise software expenditure is on installation and maintenance of software
- Data centers typically consume up to 100 times more per square foot than a typical office building
- Average power consumption per server quadrupled from 2001 to 2006.
- Number of servers doubled from 2001 to 2006

Energy Conservation and Data Centers

- Standard 9000 square foot costs $21.3 million to build with $1 million in electricity costs/year
- Data centers consume 1.5% of our Nation's electricity (EPA)
  - .6% worldwide in 2000 and 1% in 2005
- Green technologies can reduce energy costs by 50%
- IT produces 2% of global carbon dioxide emissions

Cloud Economics

- Estimates vary widely on possible cost savings
- "If you move your data centre to a cloud provider, it will cost a tenth of the cost." – Brian Gammage, Gartner Fellow
- Use of cloud applications can reduce costs from 50% to 90% - CTO of Washington D.C.
- IT resource subscription pilot saw 28% cost savings - Alchemy Plus cloud (backing from Microsoft)
- Preferred Hotel
  - Traditional: $210k server refresh and $10k/month
  - Cloud: $10k implementation and $16k/month

Cloud Economics

- George Reese, founder Valtira and enStratus
  - Using cloud infrastructures saves 18% to 29% before considering that you no longer need to buy for peak capacity

Cloud Computing Case Studies and Security Models
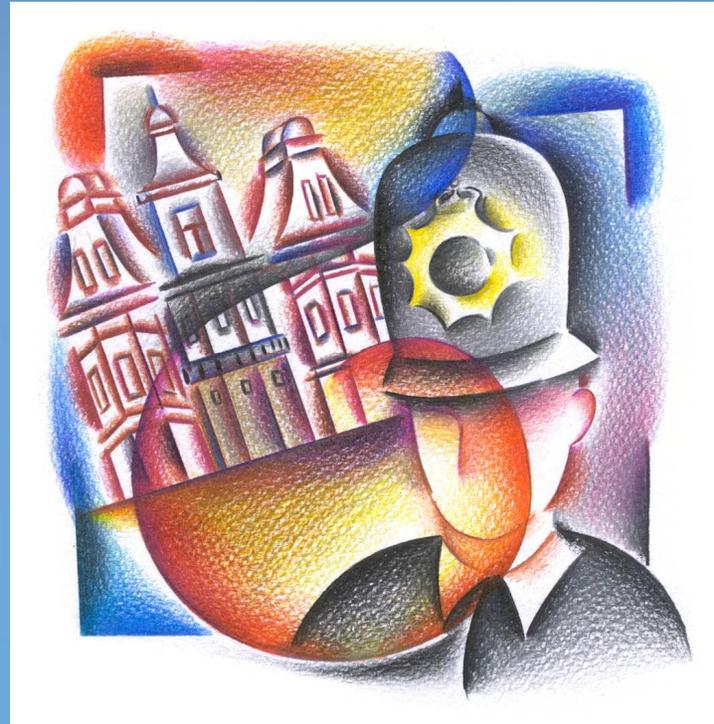
Google Cloud User:
City of Washington D.C.

- Vivek Kundra, CTO for the District (now OMB e-gov administrator)
- Migrating 38,000 employees to Google Apps
- Replace office software
  - Gmail
  - Google Docs (word processing and spreadsheets)
  - Google video for business
  - Google sites (intranet sites and wikis)
- "It's a fundamental change to the way our government operates by moving to the cloud. Rather than owning the infrastructure, we can save millions.", Mr. Kundra

- 500,000+ organizations use Google Apps
- GE moved 400,000 desktops from Microsoft Office to Google Apps and then migrated them to Zoho for privacy concerns

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Are Hybrid Clouds in our Future?

- OpenNebula
- Zimory
- IBM-Juniper Partnership
  - "demonstrate how a hybrid cloud could allow enterprises to seamlessly extend their private clouds to remote servers in a secure public cloud..."
- VMWare VCloud
  - "Federate resources between internal IT and external clouds"

vCloud Initiative

- Goal:
  - "Federate resources between internal IT and external clouds"
  - Application portability
  - Elasticity and scalability, disaster recovery, service level management
- vServices provide APIs and technologies

Microsoft Azure Services

Windows Live · Microsoft Office Live · Microsoft Exchange Online · Microsoft SharePoint Online · Microsoft Dynamics CRM Online

Azure™ Services Platform

Live Services · Microsoft .NET Services · Microsoft SQL Services · Microsoft SharePoint Services · Microsoft Dynamics CRM Services

Windows® Azure™

Source: Microsoft Presentation, A Lap Around Windows Azure, Manuvir Das

Windows Azure Applications, Storage, and Roles

n

m

LB

Web Role

Worker Role

– Cloud Storage (blob, table, queue)
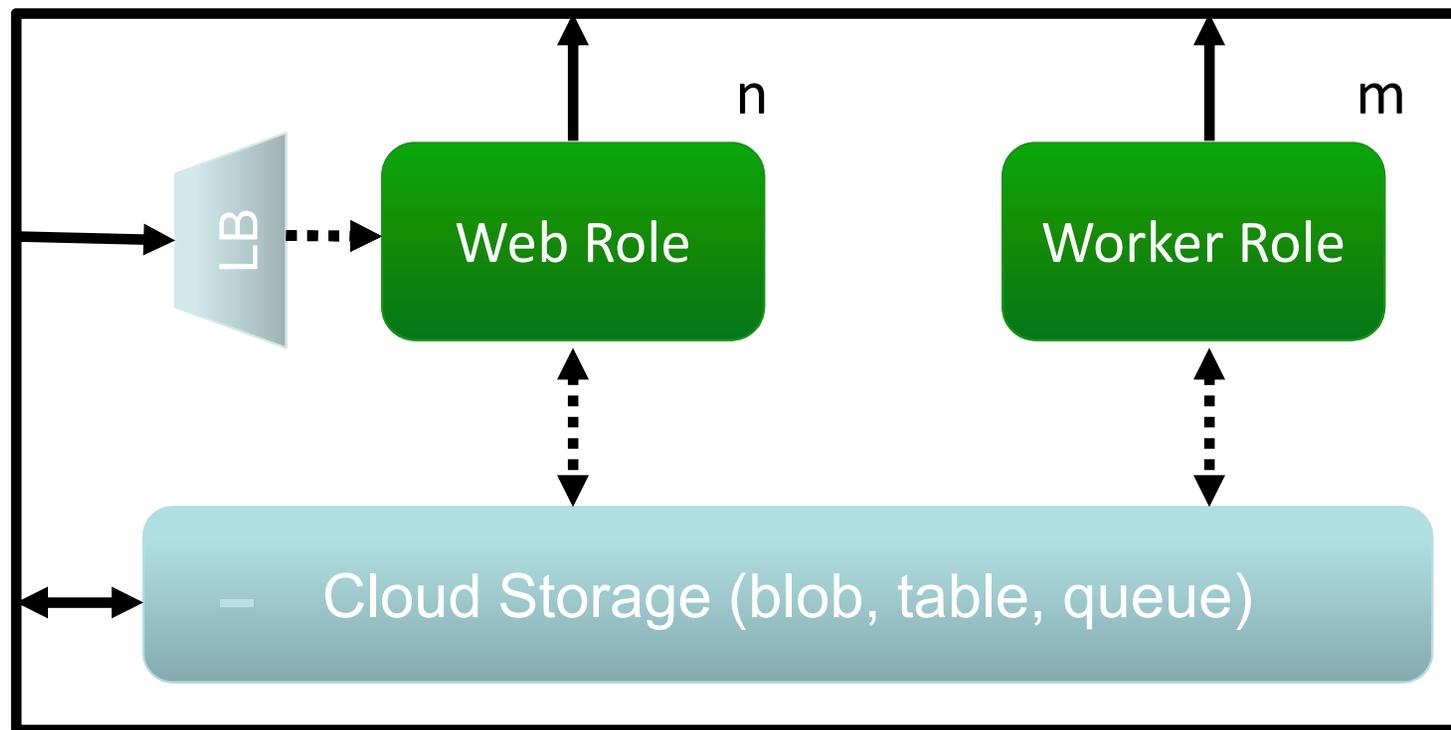
Source: Microsoft Presentation, A Lap Around Windows Azure, Manuvir Das

Case Study: Facebook's Use of Open Source and Commodity Hardware (8/08)

- Jonathan Heiliger, Facebook's vice president of technical operations
- 80 million users + 250,000 new users per day
- 50,000 transactions per second, 10,000+ servers
- Built on open source software
  - Web and App tier: Apache, PHP, AJAX
  - Middleware tier: Memcached (Open source caching)
  - Data tier: MySQL (Open source DB)
- Thousands of DB instances store data in distributed fashion (avoids collisions of many users accessing the same DB)
- "We don't need fancy graphics chips and PCI cards," he said. "We need one USB port and optimized power and airflow. Give me one CPU, a little memory and one power supply. If it fails, I don't care. We are solving the redundancy problem in software."

Case Study: IBM-Google Cloud (8/08)

- "Google and IBM plan to roll out a worldwide network of servers for a cloud computing infrastructure" – Infoworld
- Initiatives for universities
- Architecture
  - Open source
    - Linux hosts
    - Xen virtualization (virtual machine monitor)
    - Apache Hadoop (file system)
      - "open-source software for reliable, scalable, distributed computing"
  - IBM Tivoli Provisioning Manager

Case Study: Amazon Cloud

- Amazon cloud components
  - Elastic Compute Cloud (EC2)
  - Simple Storage Service (S3)
  - SimpleDB
- New Features
  - Availability zones
    - Place applications in multiple locations for failovers
  - Elastic IP addresses
    - Static IP addresses that can be dynamically remapped to point to different instances (not a DNS change)

Amazon Cloud Users:
New York Times and Nasdaq
(4/08)

- Both companies used Amazon's cloud offering
- New York Times
  - Didn't coordinate with Amazon, used a credit card!
  - Used EC2 and S3 to convert 15 million scanned news articles to PDF (4TB data)
  - Took 100 Linux computers 24 hours (would have taken months on NYT computers
  - "It was cheap experimentation, and the learning curve isn't steep." – Derrick Gottfrid, Nasdaq
- Nasdaq
  - Uses S3 to deliver historic stock and fund information
  - Millions of files showing price changes of entities over 10 minute segments
  - "The expenses of keeping all that data online [in Nasdaq servers] was too high." – Claude Courbois, Nasdaq VP
  - Created lightweight Adobe AIR application to let users view data

Case Study:
Salesforce.com in Government

- **5,000+ Public Sector and Nonprofit Customers use Salesforce Cloud Computing Solutions**

- **President Obama's <u>Citizen's Briefing Book</u> Based on Salesforce.com Ideas application**
    - Concept to Live in Three Weeks
    - 134,077 Registered Users
    - 1.4 M Votes
    - 52,015 Ideas
    - Peak traffic of 149 hits per second

- **US Census Bureau Uses Salesforce.com Cloud Application**
    - Project implemented in under 12 weeks
    - 2,500+ partnership agents use Salesforce.com for 2010 decennial census
    - Allows projects to scale from 200 to 2,000 users overnight to meet peak periods with no capital expenditure

Case Study:
Salesforce.com in Government

- **New Jersey Transit Wins InfoWorld 100 Award for its Cloud Computing Project**
  - Use Salesforce.com to run their call center, incident management, complaint tracking, and service portal
  - **600%** More Inquiries Handled
  - **0** New Agents Required
  - **36%** Improved Response Time

- **U.S. Army uses Salesforce CRM for Cloud-based Recruiting**
  - U.S. Army needed a new tool to track potential recruits who visited its Army Experience Center.
  - Use Salesforce.com to track all core recruitment functions and allows the Army to save time and resources.

Questions?

- Peter Mell
- NIST, Information Technology Laboratory
- Computer Security Division

- Tim Grance
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- Computer Security Division

Contact information is available from:
http://www.nist.gov/public_affairs/contact.htm